National Aeronautics and
Space Administration

Making Replacement Parts on Orbit and Beyond, and Returning Vitality and Jobs to Local Companies

NASA's Manufacturing Innovation Project (MIP) is working to improve the U.S. trade balance by helping local companies and universities develop and use new technologies to reduce costs, improve quality, and bring new products to market.

Because NASA's Game Changing Development Program funds MIP, our main goal is to sustain humans and hardware during long journeys in our solar system and beyond. To meet this goal, MIP will develop innovative ways to make high-quality, reliable replacement parts on other worlds. The parts have to be made with very little help from humans.

Another MIP goal is to improve the local economy and manufacturing in Cleveland, Ohio, by (1) helping small- and medium-sized companies use NASA processes and tools to compete globally and (2) involving local students in hands-on projects to encourage them to pursue careers in science, technology, engineering, and mathematics.

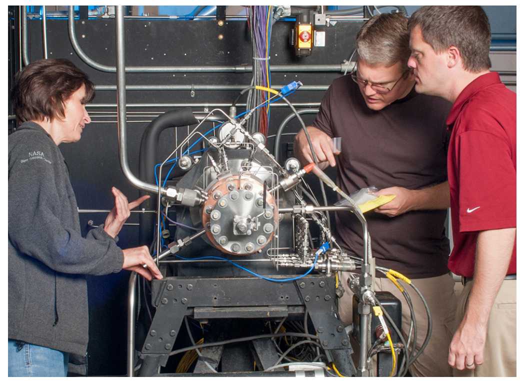
MIP is advancing three breakthrough technologies: (1) additive manufacturing (AM) with Selective Laser Melting (SLM), (2) electron beam free form fabrication (EBF^3), and (3) electron beam melting (EBM) with digital manufacturing, modeling, and simulation.

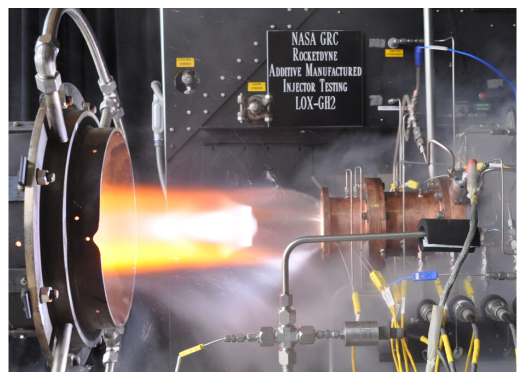
From Metal Powder to Rocket Engine Parts

Aerojet Rocketdyne and the NASA Glenn Research Center designed, built, and tested a subscale model injector that could be scaled up for use in new rocket engine designs.

AM with SLM was used to build the injector. With this process, a laser melts metal powder to build up a solid part, layer by layer, according to a computer model. The Air Force Research Laboratory conducted cold-flow tests for this effort.

Additional process development will be needed before rocket engine manufacturers can make AM injectors in a production environment. With the improved process, companies will be able to make injectors in days instead of months and for about 1/10th of the previous cost.





Top: NASA Glenn engineers installing Aerojet Rocketdyne hardware on the test stand. Bottom: Rocket injector assembly built by AM being hot-fire tested at NASA Glenn.

Testing AM Samples for a Future International Space Station System

The MIP team selected parts from the Urine Processor Assembly of the International Space Station's (ISS's) second-generation Environmental Control and Life Support System (ECLSS) to show how AM can be applied to critical ISS systems. The NASA Langley Research Center and NASA Marshall Space Flight Center built the parts with EBF^3 and EBM, respectively, using aerospace-grade titanium metal alloys that will be used in future NASA life support systems.

game changing development

In preparation for possible future ECLSS work, samples made by EBM and EBF^3 were tested in an acidic environment for a month to determine their resistance to corrosion, and parts made by EBF^3 and EBM were tested for tensile strength. These tests not only compared the EBF^3 and EBM processes, they proved that AM parts could withstand the environment on the ISS or in any planetary life support system.

"Growing" Metal Parts With EBF^3

NASA Langley created EBF^3 to make replacement parts in zero gravity. The process uses an electron beam to melt a solid metal wire to "grow" parts as it deposits the molten metal layer by layer. For MIP, Langley will add thermal measuring and imaging devices and will create a thermodynamic computer model that can be used with EBF^3. The model will guide the growing process and will record strength, microstructure, and mechanical property data.

The improved EBF^3 system and model could reduce the cost and time for repairing, certifying, and replacing parts in space by 50 percent and will allow astronauts to make parts and tools on the Moon or a planet, whenever needed.

Automated Inspection and Finishing

NASA Marshall is developing the System to Autonomously Inspect and Machine Additively Manufactured Parts (SAIMAP) to inspect, model, and finish to specifications any part created by EBF^3, EBM, SLM, or other AM techniques. The SAIMAP improves quality and supports the certification of parts without human interaction.

NASA Marshall acquired a robot, a structured light scanner, and a mill to integrate into the SAIMAP. Software work to integrate all three components into a seamless autonomous finishing system is ongoing. NASA Marshall has developed "intelligent machine" software for robot-scanner interaction so that all angles of a unique AM part can be scanned completely. The scan can be compared with the computer-aided design model from which the part was printed to determine if the part meets specifications. If not, a mill tooling path will be generated and applied with the SAIMAP mill to machine the part. The first samples processed through the SAIMAP will be the ECLSS parts built by the MIP team with EBF^3 and EBM.

The final SAIMAP process could reduce production times and costs by 80 to 90 percent, material waste by 30 percent, the mass and volume that needs to be launched by 75 percent, and the times when astronaut work has to stop by at least 50 percent.

Help for Local Companies

The MIP is supporting the Strong Cities, Strong Communities (SC2) White House Initiative to help struggling cities make the best use of Government opportunities. Glenn "mentors" will help small- and medium-sized enterprises in the City of Cleveland and Cuyahoga County solve technical challenges to increase profits, create jobs, and help companies compete globally. MIP is also supporting the Midwest Project that will provide manufacturers with computer-based modeling and simulation and analysis software. In addition, research and development time will be shortened as the partners share their knowledge with each other.

Hands-On Experience for Students

Glenn is including Case Western Reserve University (CWRU) students in real-world manufacturing projects with a local company. In addition, Glenn and CWRU will develop classes so that students can get hands-on experience with the processes and digital tools that industry uses in creating, manufacturing, maintaining, and disposing of products. Working on realistic, meaningful projects in space and technology will encourage the students to pursue careers in science, technology, engineering, and mathematics.

Student using the EBM process to build a part.

The Game Changing Development (GCD) Program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

For more information about GCD, please visit http://gameon.nasa.gov/

PS-00897–0713